Fram Centre

COAT

CLIMATE-ECOLOGICAL OBSERVATORY FOR ARCTIC TUNDRA

Ecosystem-based long-term research in the Arctic

Eeva Soininen 11.10.2018

University of Tromsø · NINA Norwegian Institute for Nature Research · Norwegian Polar Institute · UNIS · Norwegian Meteorological Institute

PURPOSE AND SCOPE OF COAT

To identify change (i.e. trends) in terrestrial arctic ecosystems beyond the realm of natural variability
⇒ Observations: Long-term, Ecosystem-based

To identify cause of change: Impact of climate change and other stressors
⇒ state-of-the art research designs & analyses

Inform policy makers and management agencies about options,
so they can decide whether to adapt, mitigate and conserve
⇒ Relevance

Contribute directly to adaptive management to assess the effect of actions
⇒ Integrate management directly to COAT

HOW TO REACH THESE GOALS?

Through an adaptive and iterative protocol:

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Conceptual models and hypotheses of the effect of climate and management

↓

Study design
Methods and design
Experimental tests of management actions

↓

Data
Data management
Open data

↓

Statistical models
Causal inference
Predictions

↓

Improved knowledge
Publication/dissemination

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Stakeholder involvement

Adapt protocol to:

Improved knowledge
↓
Improved models
↓
New predictions
↓
Adjusted design
↑
New technology

EXAMPLE: HOW TO INTEGRATE MANAGEMENT TO COAT?

Logging as management tool after moth outbreak

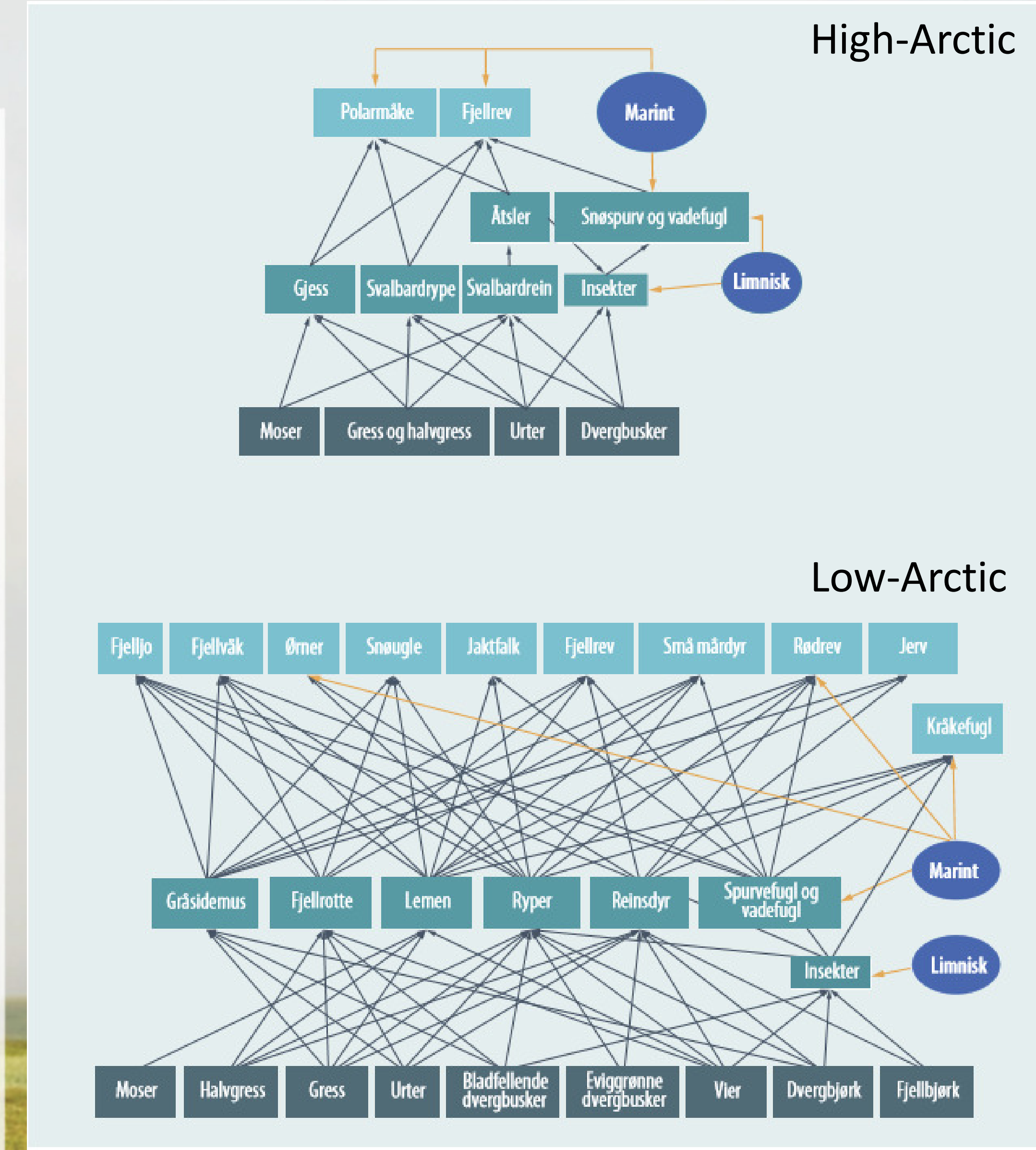
- Large areas of dead forest
- Management authorities recommended logging
- Effect never estimated

- Large-scale logging experiment in 2011
- Planned together with management authorities
- All parts contribute financially
- Management authorities logged
- COAT researchers follow up the sites

Vindstad, Jepsen et al. (2017). Forest Ecol Manage.
Popular scientific text: www.framsenteret.no

‘ECOSYSTEM BASED’ – HOW TO DO THAT?

- COAT employs *food-web approach*
- Climate change impacts often through trophic pathways
- Established ecological theory (~100 years)
- Human impacts through food webs (harvesting, management)
- Ecosystem services and biodiversity explicitly included
- Arctic food webs are known well enough to escribe them

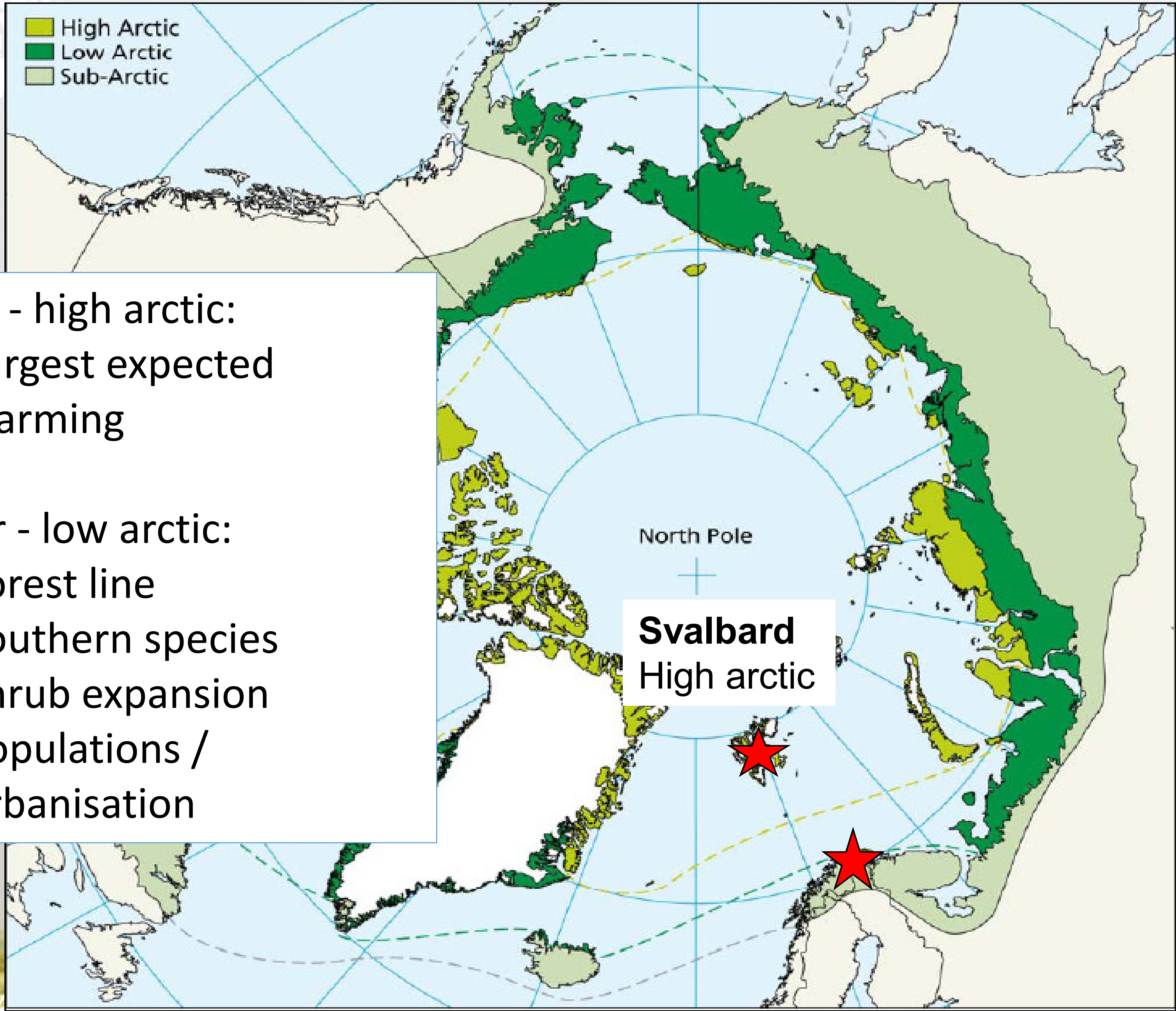


Svalbard - high arctic:

- Largest expected warming

Varanger - low arctic:

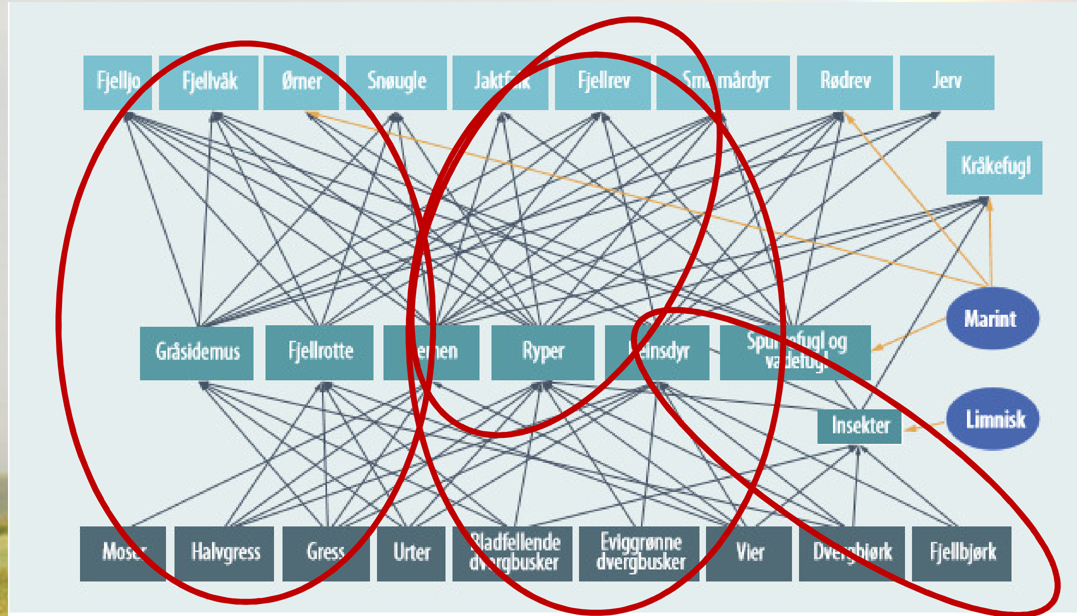
- Forest line
- Southern species
- Shrub expansion
- Populations / urbanisation



HOW TO ANALYSE COMPLEX ECOSYSTEMS?

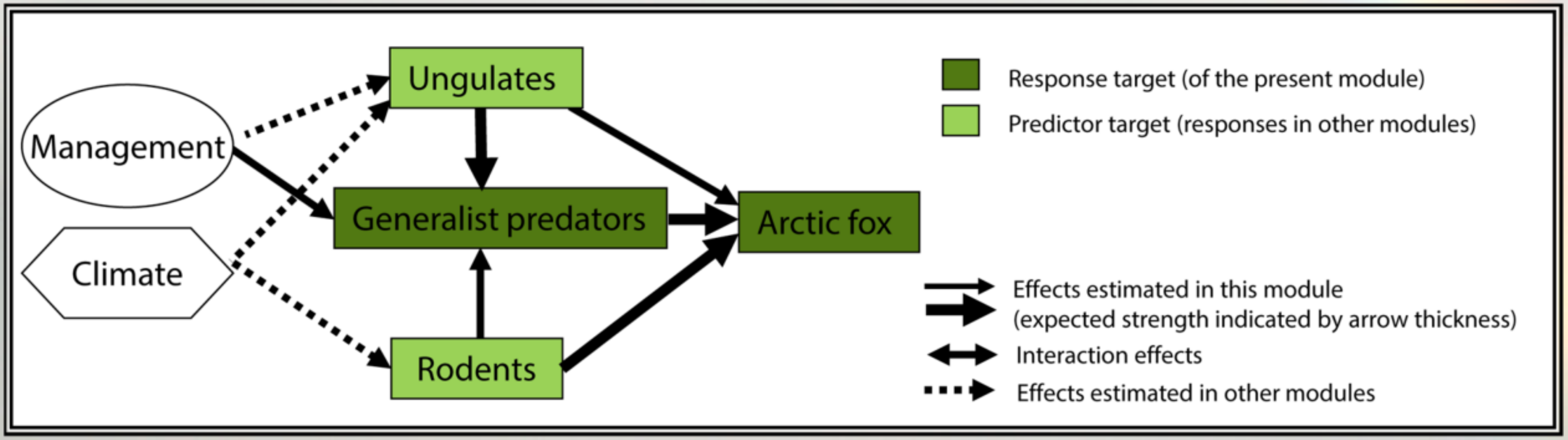
Food web modules
- ➢ Central species/assemblages/interactions of the system
- ➢ Key ecosystem services and management relevance
- ➢ High sensitivity to climate change

- ➢ 8 ecology modules
- ➢ 4 of these both in the High and Low Arctic
- ➢ 1 climate module



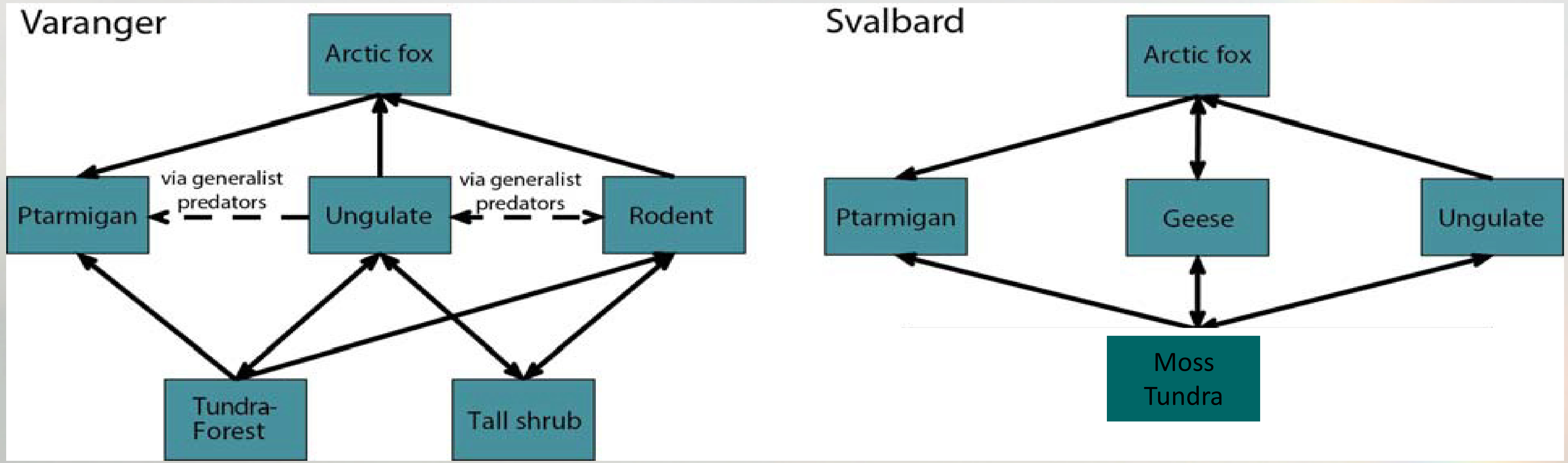
Each food web module has a conceptual model describing the expected effect of climate, management, and other ecosystem components

An example with Low-Arctic «arctic fox module»



- simple and effective (powerful)
- *identify status of knowledge*
- To be continuously improved

MODULE SPECIFIC MODELS ARE LINKED

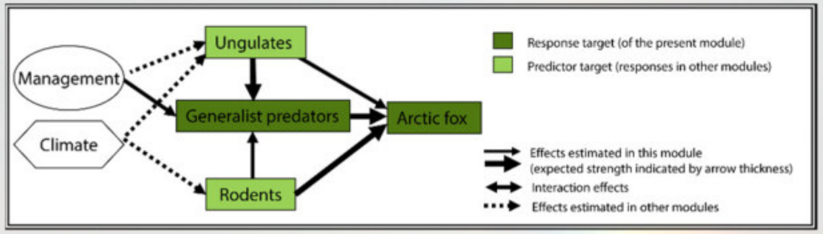


- Modules are linked by trophic and non-trophic interactions

STATE OF EACH «TARGET» IN MODELS IS MONITORED BY MEASURING STATE VARIABLES

Examples for arctic fox

- Number of litters, number of young
- Disturbance of dens (red fox)
- Genetic identity and population structure
- Diet



Target	State variable	Interval (start)	Methods (references)	Module relevance*
Arctic fox	Size of breeding population and reproductive success	1 yr (2004)	Inventories and camera traps at dens in summer (Meijer et al. 2011)	2.4, 2.8
	Disturbance on arctic fox dens by red fox and golden eagle	1 yr (2012)	Camera traps at dens (Meijer et al. 2011)	2.8
	Genetic identity (species- and individual-level), genetic population structure	1 yr (2010)	Scat samples at dens, samples of fur (Ehrich et al. 2012b)	2.8
	Late summer/early autumn and winter diet	Seasonal (2007)	Stable isotope analysis of winter fur (Killengreen et al. 2011)	2.4, 2.8

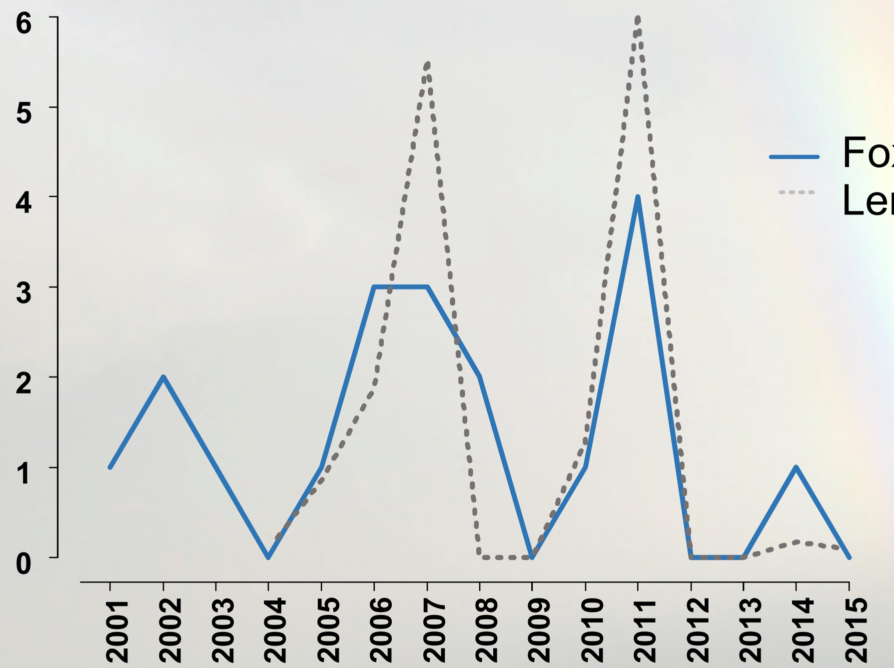
Time-series of many state variables already collected as part of separate initiatives

EXAMPLE: MONITORING OF EACH TARGET TOGETHER WITH COUPLED ECOSYSTEM AND CLIMATE COMPONENTS

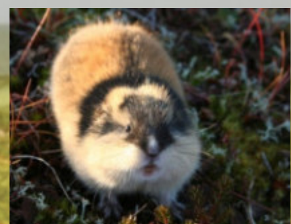
Arctic fox reproduction in 2007 and 2011

Fox prey:
«reproduction requires lemmings, other rodent species are not enough»

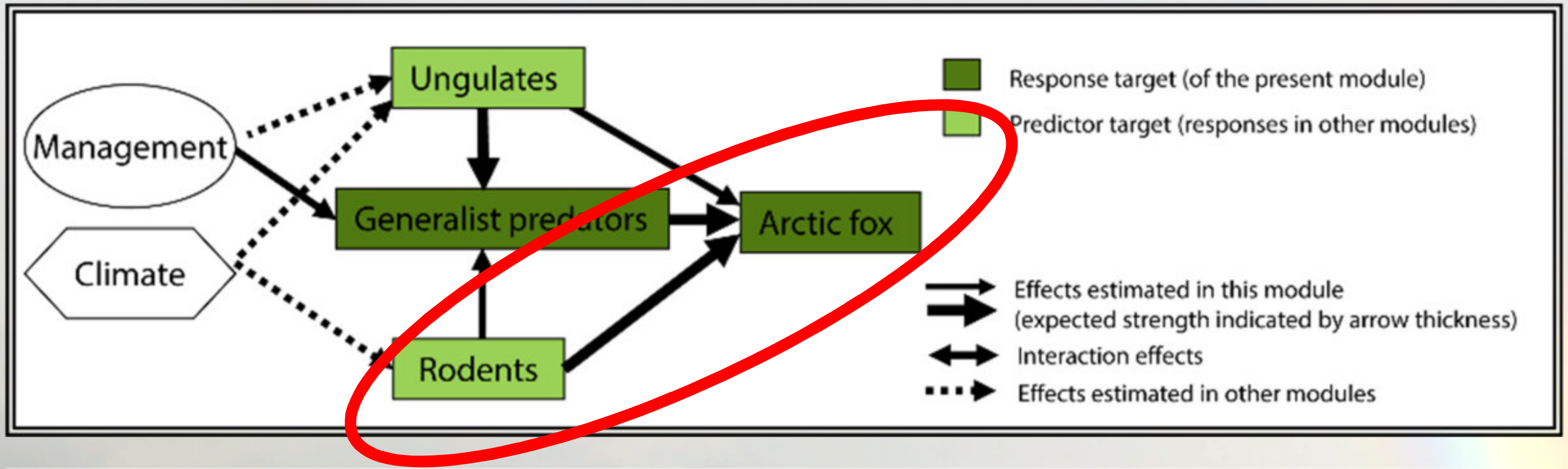
Snow conditions :
«lemmings more affected by mild winters than other rodents?»



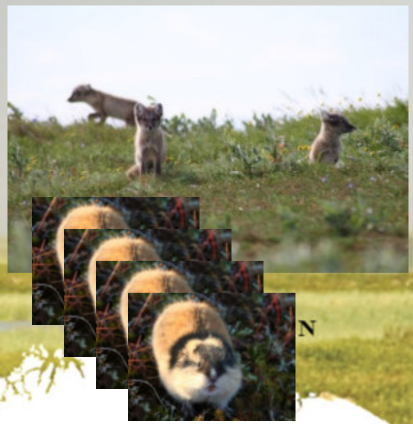
Ims et al. (2017). Polar Biol.

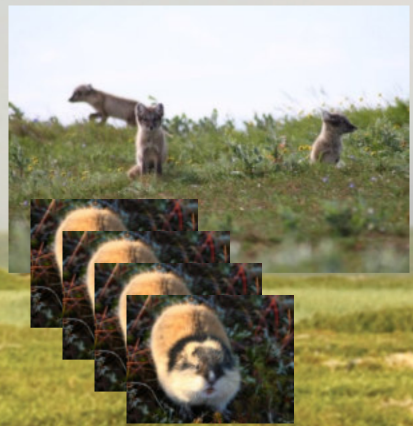


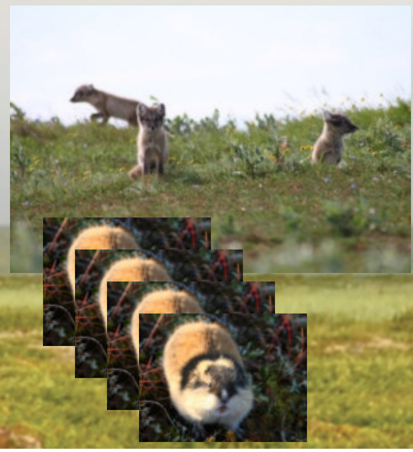
HOW TO HIT THE RELEVANT SCALES IN TIME IN SPACE?



Annual variation in fox reproduction, rodent prey abundance; annual monitoring of both







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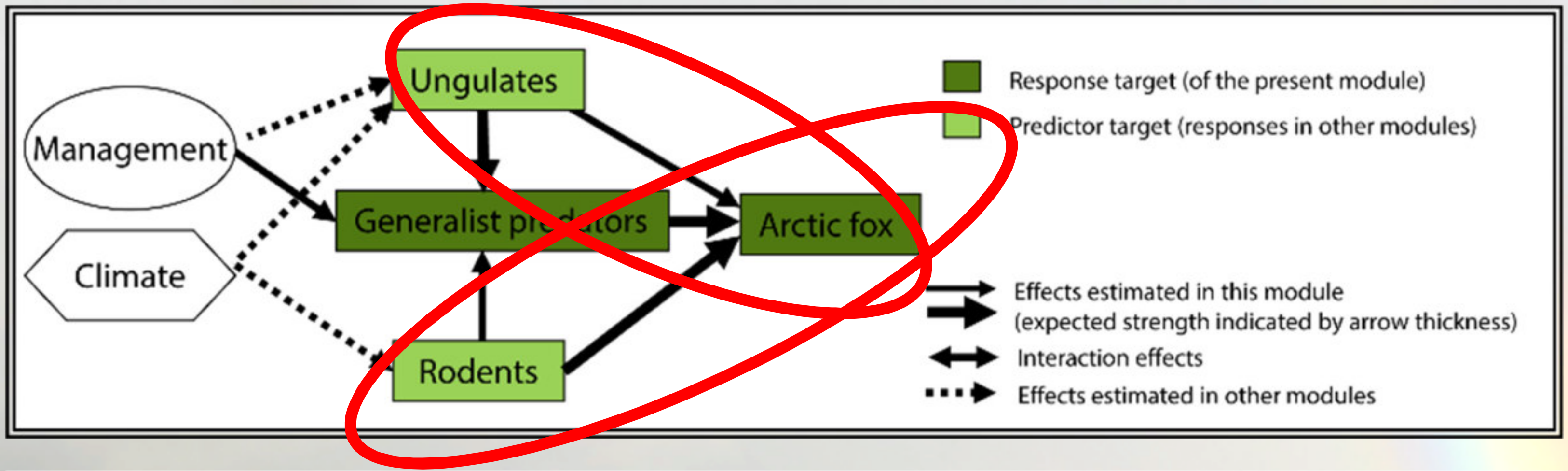

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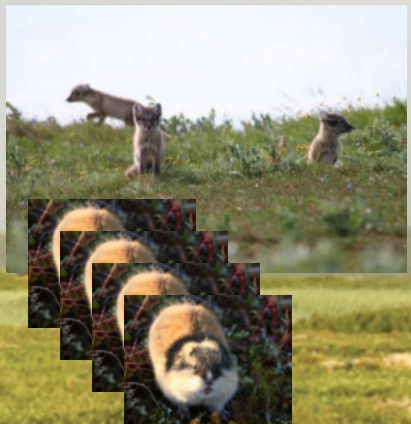

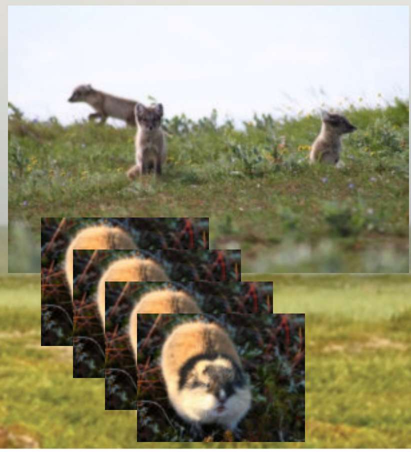

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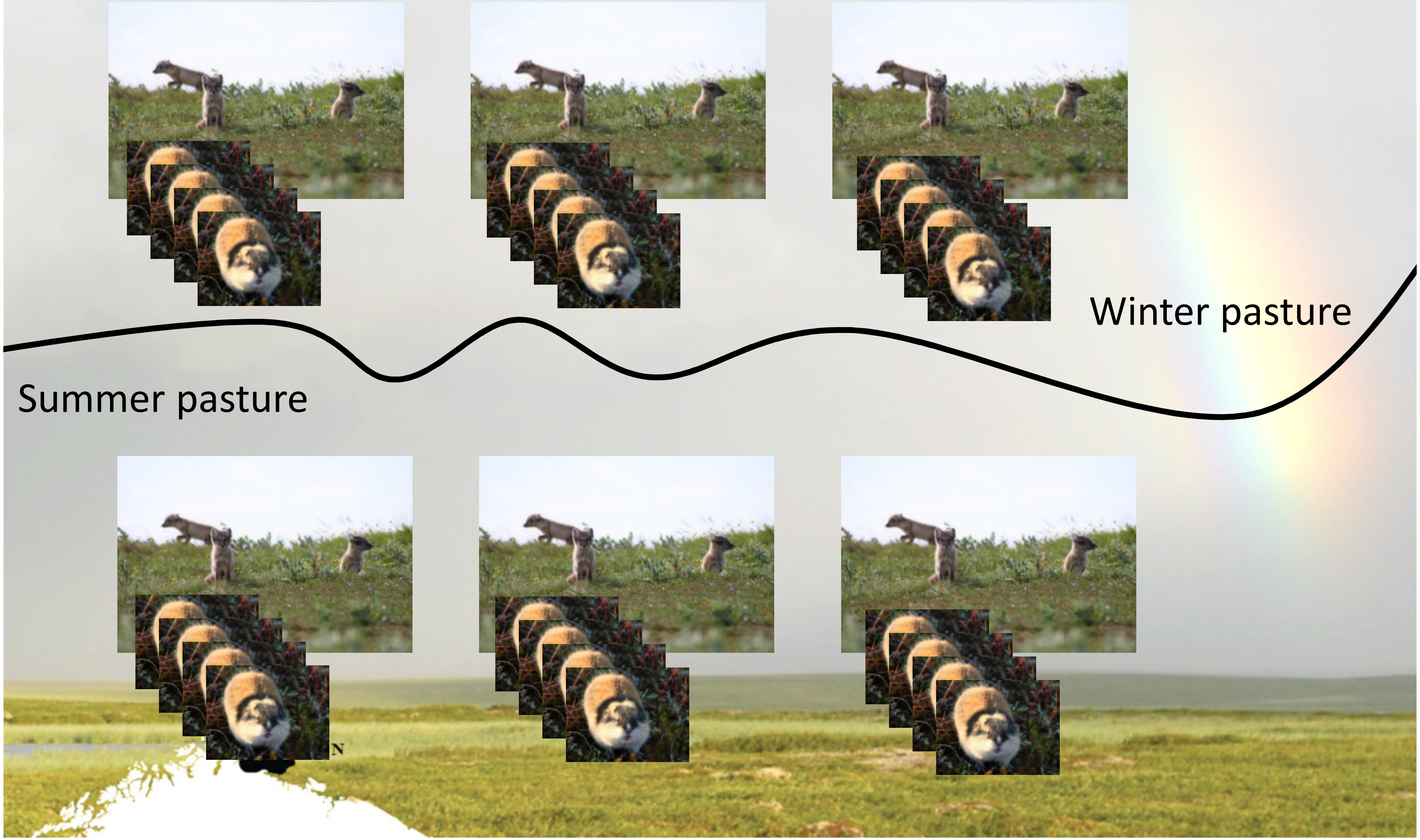
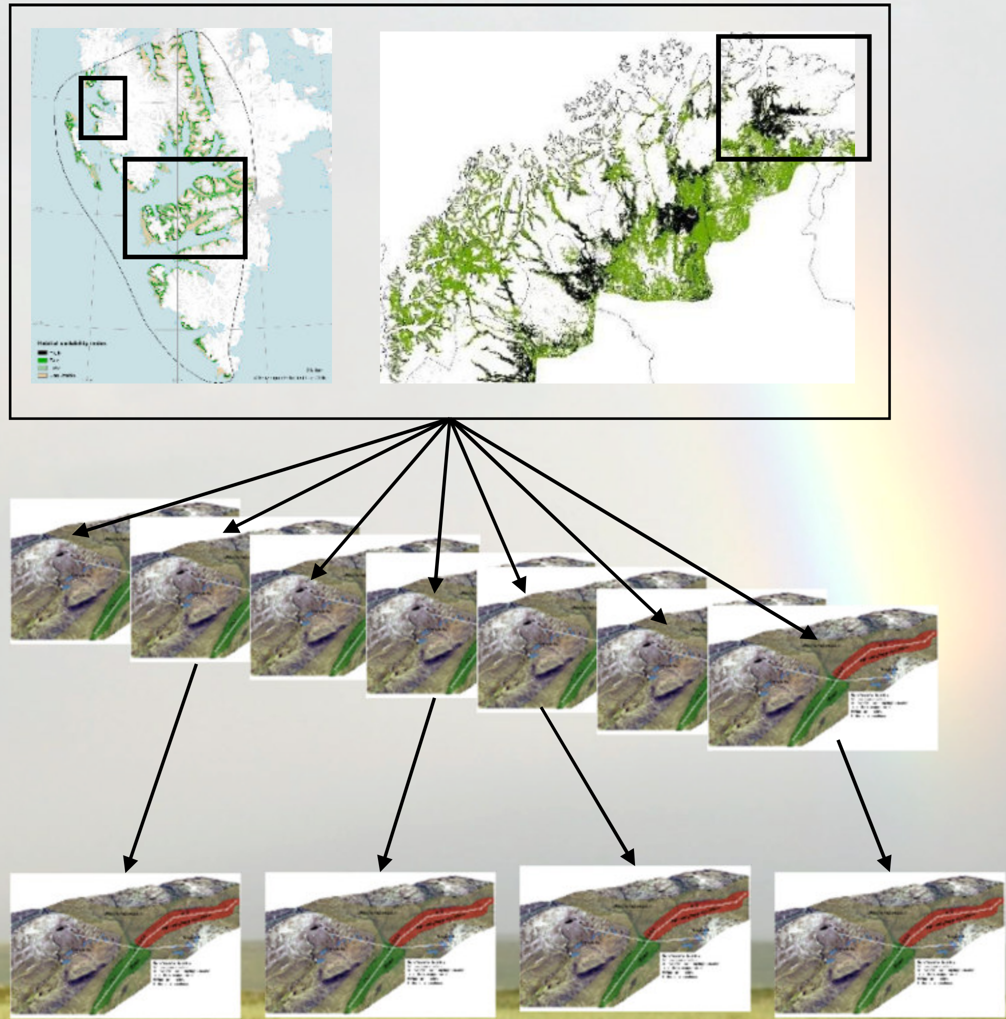


HOW TO HIT THE RELEVANT SCALES IN TIME IN SPACE?

Hierarchical design with 3 levels:

Locality (Svalbard-Mainland):
Remote sensing



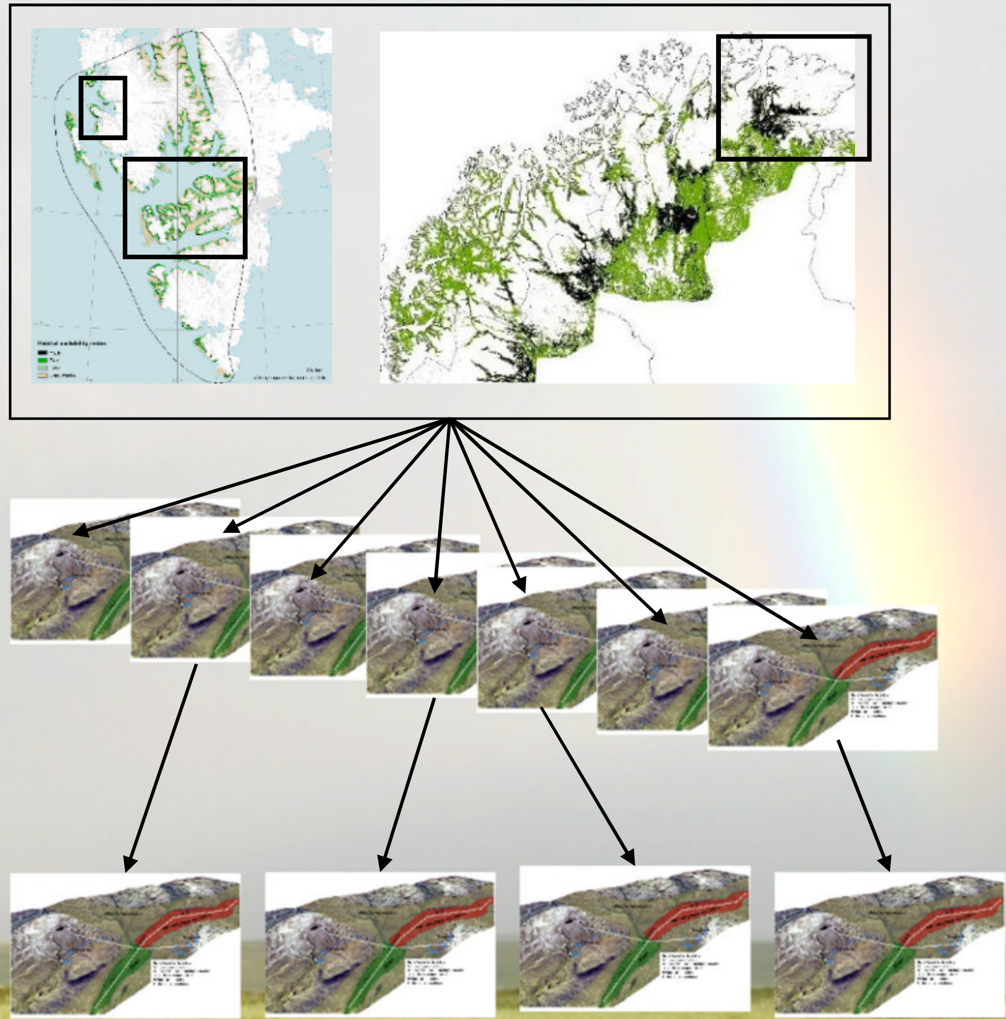
Regional extensive :
Field sampling of slowly responding variables
(long registration intervals)

Regional intensive:
Field sampling of quickly responding variables
(annual/seasonal sampling)

HOW TO HIT THE RELEVANT SCALES IN TIME IN SPACE?

Replicate sites placed in sub-regions with different climate (continentality) and management regimes (harvesting levels).

Climate (incl. snow) state variables with a matching design



CONCEPTUAL MODELS WILL FEED TO STATISTICAL MODELS

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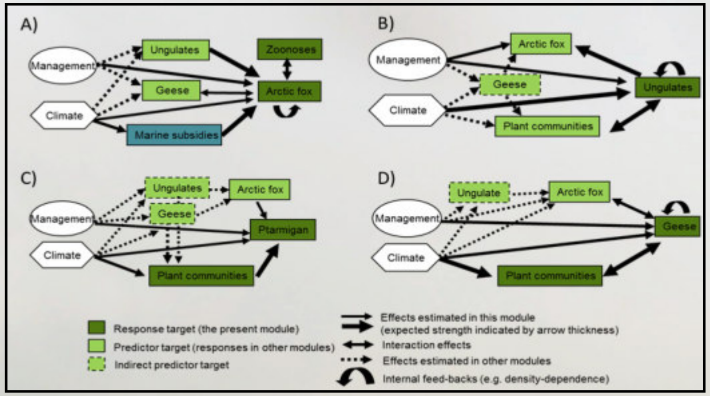
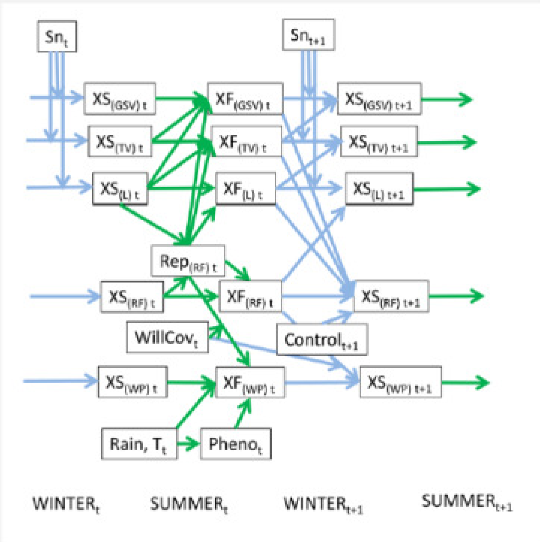
Conceptual models



State variables

Target	State variable	Interval (start)	Methods (references)	Module
Plant communities	Quantity and quality of goose and reindeer forage plants in marshes: Grasses/sedges	1 yr	Biomass/leaf area index and protein content in selected plants and plots at time of hatch (Pettorelli et al. 2011; ITEX Protocol, www.geog.ubc.ca/itex; Madsen et al. in prep.)	2.5, 2.7
	Pink-footed goose grubbing impact on fen habitats	1 yr (2003)	Quadrat and point-intercept sampling of vegetation cover and composition on fixed transects along altitudinal transects (Madsen et al. 2011)	2.6, 2.7
	Abundance (biomass) and phenology of spring/summer herbivore forage plants: Altitudinal gradients: Polar willow (Salix polaris) and Bistorta (Bistorta vivipara)	1 yr	Abundance estimation by: point intercept method (Bråthen and Hagberg 2004) Estimation of phenology-temperature curves	2.6, 2.7
Geese	Pink-footed Goose (PG) and Barnacle Goose (BG) breeding	1 yr (PG 2003, BG	Colony surveys in selected plots (Madsen et al. 2007)	2.7, 2.8

Statistical models: causality and prediction



Structural equation models

COAT STATUS TODAY

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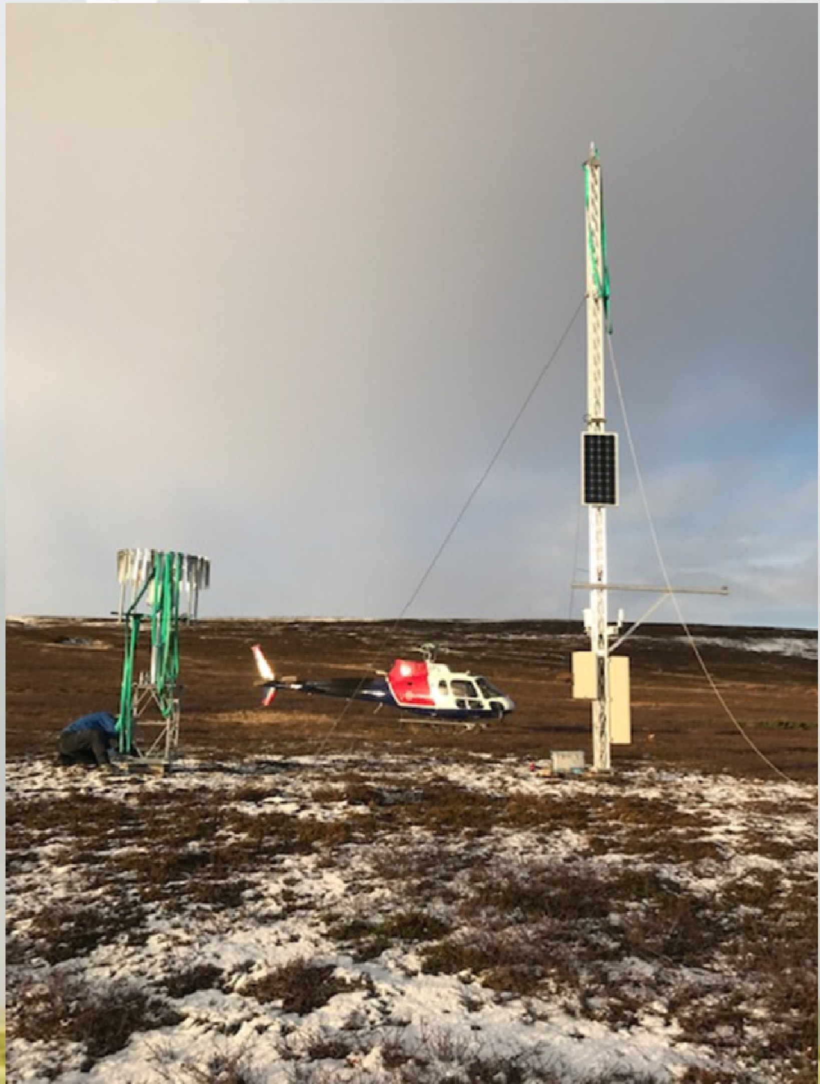

- Published science plan *(Ims et al. 2013)*
- Infrastructure establishment project (2016-2020)
  - Field instrumentation
  - Field logistics
  - Data storage and sharing portal
- Method development project COAT Tools
  - 7 PhD students
- From 2020 onwards – COAT Science fully up and running – we hope!

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COAT team (2018)

UiT – Arctic University of Norway
Dorothee Ehrich
Eeva Soininen
Eivind Flittie Kleiven
Francisco Javier Ancin
Ingrid Jensvoll
Jan Erik Knutsen
John-Andre Henden
Hanna Böhner
Isabell Eischeid
Kari Anne Bråthen
Kelsey Lorbeau
Lorena Munoz
Malin Ek
Marita Anti Strømeng
Nigel G. Yoccoz
Ole Petter Vindstad
Rolf A. Ims
Sigrid Engen
Siw Killengreen
Vera H. Hausner

Norwegian Institute for Nature Research
Audun Stien
Erling Johan Solberg
Ingunn Tombre
Jane U. Jepsen
Torkild Tveraa

Norwegian Polar Institute
Eva Fuglei
Jack Kohler
Jean-Charles Gallet
Virve Ravolainen
Åshild Ønvik Pedersen

The University Centre in Svalbard
Ingibjörg Svala Jónsdottir
Mads Forchhammer

Norwegian Meteorological Institute
Bernt Enge Larsen
Herdis Motrøen Gjelten
Ketil Isaksen
Ole Einar Tveito

Norwegian University of Life Sciences
Leif Egil Loe

University of Aberdeen
Rene Van Der Wal

Aarhus University
Jesper Madsen